FLUID FLOW MOTION REDUCTION SYSTEM

FIELD OF THE INVENTION

This invention relates to linear displacement mechanisms, and more particularly, to a linear displacement mechanism which uses the principles of fluid flow motion reduction to achieve minute linear displacements.

BACKGROUND OF THE INVENTION

Precise and accurate optical, electronic, and mechanical devices require a simple, low cost and backlash-free linear or rotational motion reduction system. In the conventional art of motion reduction mechanisms, such as those employed in micropositioners and micromanipulators, large reductions in displacement often bring about large increases in applied force. However, the application of large forces are often unnecessary and even undesirable because they can deform and damage delicate objects. Where motion reduction is required, such as those mechanisms where a significant linear displacement needs to be translated (to a proportional but substantially smaller linear displacement,) but precise positional locations are not absolutely required, heretofore alternative mechanisms to the standard gears and screws found in small displacement mechanisms such as micrometers have not always met optimum requirements.

What is needed is a method of motion reduction wherein the motion reduction system provides for proportional reduction in linear displacement without the introduction of large increases in applied force.

SUMMARY OF THE INVENTION

The present invention is directed to a fluid flow motion reduction apparatus and system wherein the principles of hydraulic phenomenon of planar Couette flow and flow of viscous Newtonian fluids are applied. Couette flow may be defined as the low-speed, steady motion of a viscous fluid between two infinite plates moving parallel to each other. "Couette flow" is a two dimensional flow, without a pressure gradient in the directionn of flow, caused by relative tangential movement of the boundary surfaces of the fluid. A "Newtonian fluid" is a fluid in which the state of stress at any point is proportional to the time rate of strain at that point; the proportionately factor is the viscosity coefficient. Newtonian fluids exhibit the Couette flow phenomenon. In particular, a set of at least three parallel flat plate members, including a top movable driving plate member, a stationary bottom plate member and an interleaved center driven plate member positioned between the top and bottom plate members are placed in parallel adjustable position and separated by two separate fluids. The first fluid is positioned between the top driving plate member and the interleaved plate member. The second fluid is positioned between the interleaved driven plate member and the bottom stationary plate member. The second fluid in the preferred embodiment is a fluid chosen to deliberately be a higher known viscosity than that of the first fluid. The distances between each set of plates in the preferred embodiment are equal. The plates may be securely separated in a relatively frictionless manner by plurality of steel balls. When force is imparted along one direction to the upper driving plate, the interleaved driven plate moves a reduced distance which is calculable and proportional to the movement in the to plate member and the ratio of the viscosities of the fluids. The ratio of the distance that the driven plate moves to the distance that the driving plate member moves, is a ratio proportional to the viscosity of the first fluid to the second fluid.

As an alternative embodiment, the fluids positioned between each of the plates may be of the same viscosity, but the spacing between the top and center driven plate may be made to be substantially greater than the spacing between the central driven plate and the lower stationary plate since the flow of the fluids is a function of the spacing between the plates as well as the viscosity. When the viscosity of both first and second fluids is the same or when the same fluid is used as first and second fluids, the relative thickness or distance between the pairs of plates provides a relationship in which the distance moved by the driving top plate to the distance moved by the driven plate is proportional to the ratio of the spacing between the driven plate and the stationary plate to the spacing between the driven plate and the driving plate.

A bidirectional, one-dimensional Couette flow apparatus is disclosed which is actuated by a joystick to allow the joystick to move a top driver plate and through a viscous fluid an interleaved driven plate within a channel, whereby the joystick is secured to a socket within a lower stationary housing. As the joystick is moved within the socket, the top driver plate moves a greater distance than the interleaved driven plate since the grease or fluid layer between the driven and driver plates is selected to have a lower viscosity than the fluid layer between the housing channel and the driven plate. In this manner, the driven plate may be moved infinitesimal distances even though the top driver plate is moved through greater distances. The distance transversed by the driven plate is a function of the planar Couette flow phenomenon because of the difference in viscosities of the two layers of grease or fluid which lie above and below the driven plate.

Additionally, a two-dimensional embodiment of the invention is disclosed which includes a joystick capable of two-dimensional X–Y axis movement mounted on to a set of at least three plates separated, layer by layer, by a first fluid of uniform viscosity and a lower plate having a second fluid of substantially greater viscosity. As the joystick of this alternative embodiment is moved in either X–Y direction or diagonally, the driven plate is caused to move a substantially smaller distance than a drive plate.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a cross-sectional Diagrammatic profile of the preferred embodiment of the fluid flow motion reduction apparatus of this invention.

FIG. **2** shows an alternative embodiment and diagrammatic profile of the fluid flow motion reduction apparatus of this invention.

FIG. **3** is a top view of a bidirectional one dimensional linear displacement Couette flow apparatus operating according to the principles of this invention.

FIG. **4** is a cross-sectional view of the linear displacement Couette flow apparatus taken along line IV—IV of FIG. **3**.

FIG. **5** is a cross-sectional view of the linear displacement Couette flow apparatus taken along line V—V of FIG. **4**.